Cross-Domain Priming of Language and Music

Research Thesis

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by

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Abstract

There is much evidence that domain-general learning is possible, but understanding the breadth of possible transfer will shed light on how different processing mechanisms are related. Evidence has shown that domain-specific transfer is possible in both the language domain and the music domain such that participants can be primed with information that later affects production in that same domain. This study used rate priming to look into cross-domain transfer between the language and music domains. Participants listened to a series of 20 recordings, either language or music stimuli, to prime a fast or a slow rate. After each prime, the participants produced a short melody or picture description in the domain opposite of the prime. Participants' rate of production was influenced by the music prime such that a faster rate of speech was spoken following a fast music prime than following a slow music prime; however, the transfer did not occur from language to music. These findings show that generalization between the music and language domains is possible supporting the presence of a shared mechanism used for processing in both domains.

Keywords: generalization; rate persistence; cross-domain

Cross-Domain Priming of Language and Music

The ability to learn and generalize new information is essential to many aspects of life. One's ability to generalize or transfer new information can enhance the learning process. For example, a child learns that their pet is a cat. Then, when the child encounters another cat, they are able to determine that it is a cat as well. This ability to generalize information beyond the original learning situation eliminates the necessity of relearning what a cat is each time the child encounters a new instance of a cat. Therefore, it is obvious that even young children are capable of some degree of generalization; however, how broadly one generalizes information is not yet well understood.

Research has shown that transfer of knowledge from one domain to another is difficult to achieve (DeLoache, 1991), and the extent to which one is capable of generalizing remains unknown (Hupp & Sloutsky, 2011). Possible explanations for the difficulties in explaining generalization concern the issues of separating the boundaries between where one domain ends and the next begins, as well as the lack of information about the origin of knowledge (Rakison & Yermolayeva, 2011). The nature of knowledge and its origin are studied throughout the developmental process in an attempt to understand and explain generalization. Two different views regarding knowledge acquisition have been hypothesized: domain-specific and domain-general.

Domain-Specific vs. Domain-General

The domain-specific view suggests the presence of specific and specialized areas of the brain that are designated to the development of certain individual cognitive abilities (Fodor, 1985). Fodor (1985) proposed that there are areas of the brain that are modular, or biologically programmed to complete some specific cognitive tasks. He argues that very little is known about many higher cognitive capabilities (i.e., thought and problem solving) and the complicated processes entailed in completing the task. Fodor says that the mechanisms utilized in the brain to complete higher level cognitive processes are encapsulated, or designated to a specific cognitive task with limited knowledge and information regarding mechanisms designated to processing other cognitive tasks. He goes on to say that the complicated process of cognitive processing includes a complex web-like structure in which information processing does not occur in a linear or structured format; instead, it is a process involving a variety of encapsulated mechanisms. And, although the encapsulated mechanisms do have a limited amount of access to the theories that drive different cognitive tasks, cognitive processing within an encapsulated mechanism is not affected or influenced by that access. According to Fodor (1985), the lack of commonality between language production and other cognitive processes (i.e., perception) provides support that separate mechanisms are utilized to complete each cognitive process. Therefore, Fodor supports the domain-specific theory by claiming that information learned in one domain does not affect processing in any other domain.

Another study tested the encapsulation of preexisting cognitive building blocks used in word recognition (Shatil & Share, 2003). The researchers administered a variety of both domain-specific (i.e., visual short term memory and rhyme detection) and domain-general tests (i.e., general ability and picture vocabulary tests) in a longitudinal study involving Hebrew speaking children from the beginning of kindergarten through first grade. The researchers found that the children’s word recognition abilities were unaffected by higher-order domain-general processes (i.e., general intelligence and higher-order reasoning) only showing influence from domain-specific tasks. The researchers argue that the lack of influence from the domain-general processes support the modularity hypothesis that word recognition is a domain-specific function (Shatil & Share, 2003).

An opposing view focusing on domain-generality suggests that knowledge in one domain can be transferred and applied to a different domain affecting processing in that new domain. A recent study demonstrated that infants are capable of generalizing and transferring information between their visual and auditory domains (Hupp & Sloutsky, 2011). By changing the end of the visual sequence to be different and exciting (i.e., the figure jumped or the picture expanded), the infants were trained to attend to the end of a visual sequence. Immediately after the visual test, the infants were given an auditory test. Results indicated that the infants also attended more to the end of the auditory sequence as a result of the visual training. By priming the infants in one domain and observing the effects in a different domain, generalization across the two domains is demonstrated.

Information supporting domain-general learning can be seen in another study testing the hypotheses that auditory language comprehension interacts with visual perception (Meteyard, Bahrami, & Vigliocco, 2007). The researchers tested 20 adults in a series of trials that required participants to complete a motion-detection task while listening to a series of verbs. The task used a series of random dot patterns that displayed upward, downward, or random movement. Pretested verbs that also implied either upward, downward, or neutral movement were randomly paired with the patterns. Participants were instructed to ignore the words (i.e., auditory information) and pay attention to the computer monitor (i.e., visual information). By comparing the participants' reaction time across the trials of correlating movement (e.g., upward movement in the visual task paired with a verb implying upward movement), mismatch movement (e.g., downward movement in the visual task paired with a verb implying upward movement) and neutral movement (e.g., upward movement in the visual task paired with a verb that did not suggest movement), researchers found that participants had the fastest reaction time when the visual stimuli matched the auditory stimuli. Even though the participants were instructed to ignore the auditory stimuli, their comprehension of the semantic meaning of the verbs affected their sensory motor processing, suggesting a domain-general mechanism is used in both visual perception and language comprehension.

Language Processing

Many other linguistic skills can also be explained through domain-generality. Research suggests that word recognition is not entirely domain-specific as it relies on other contextual information. A person's understanding of semantics (the word's meaning) and syntax (the rules of the language) paired with more complex domain-general cognitive processes may affect their ability to process and learn language. This has prompted language development to be a common area of study when researching domain generality versus domain specificity. Recent research on generalization in the domain of language tested participants ages 2 ½ to 5 on a novel noun generalization task (Vlach & Sandhofer, 2011). The researchers varied the backdrop of the visual stimuli (e.g., changing the color and/or pattern), then tested for changes in word learning abilities. They found that by changing the contextual information, the child's word learning abilities were negatively affected. This suggests generalization of language learning was affected by the visual domain. Evidence of a relationship between memory, word learning, and generalization (as demonstrated in this study) suggests that word learning relies on information from more than one domain (Vlach & Sandhofer, 2011).

Research into other influences of language processing has looked into the importance of a word's beginning. It has been shown that a word's beginning is the most integral part of the word for language processing and word recognition; variations to the end (e.g., ham/hams) has less of an impact than variations to the beginning (e.g., ham/sham; Dryer, 2005). In a recent study, it was demonstrated that participants exhibit this same preference in both the musical and visual domains (Hupp, Sloutsky, & Culicover, 2009). A stimulus was altered so there was either an addition to the beginning or an addition to the end of a sequence of visual, language, or musical stimuli. Participants continued to rate two sequences as more similar if their beginnings were the same in comparison to when they shared the same sequence endings. However, after participants were trained to attend to the end of a visual sequence, they lessened their reliance on the beginning of the language sequence to infer a word's meaning. The ability to shift preferences across domains after training suggests that some linguistic skills can be explained by general cognitive functions.

Rate Persistence in Language and Music

Rate persistence, the tempo or timing of received information and it's reoccurrence in future tasks (e.g., Hupp & Jungers, 2009; Jungers & Hupp, 2009), is often used to measure within-domain processing and can be utilized to measure transference in cross-domain tasks as well. A typical example is that when one person hears a person speaking quickly, this will in turn affect their own rate of speech production. Evidence of rate transfer in the domain of language can be seen in two recent studies, involving both children (Hupp & Jungers, 2009) and adults (Jungers & Hupp, 2009). After being shown pictures that were accompanied with a fast or slow auditory prime describing the action taking place in the picture, participants were asked to repeat the sentence. A new picture was then displayed, and the participants were asked to create a description of the new picture. The researchers found that both the children and the adults transferred the primed rate (either fast or slow) to their produced speech such that hearing a fast prime resulted in a faster rate of production than did a slow prime.

Similarly, in research conducted with musicians, rate priming has shown evidence of affecting the rate at which new music is created and performed. For example, Jungers, Palmer, and Speer (2002) demonstrated that pianists produced faster musical melodies after listening to a fast music prime than after listening to a slow music prime. Another study using rate persistence to determine within-domain transfer in non-musicians showed similar results (Levitin & Cook, 1996). The participants were asked to sing popular pop songs from memory. The researchers found that the songs were recreated at a similar tempo to that of the original song. Although the researchers used a wide range of tempos in their song selection to reduce productions being attributed to reproduction of a specific tempo, there is a question regarding whether or not this could be considered rate persistence or simply evidence of learning.

Most notably, by demonstrating rate persistence in non-musicians and in the domain of language, rate persistence appears to be a cognitive processing mechanism rather than a musician’s learned skill. This same type of rate priming method can also be used to measure transfer from one domain to another; for example, if participants are primed in one domain (e.g., music) and tested in a different domain (e.g., language), variance in rate persistence can be used to determine transfer possibilities. One thing that could be impactful if rate persistence is a cognitive processing mechanism potentially able to cross domains, could be incorporating music into speech therapies. With the presence of a shared mechanism, gains in one domain could lead to gains in an alternate domain. Therefore, things such as stuttering could possibly be helped by adding music into speech therapies. Similarities would suggest transfer, supporting a domain-general view.

The Current Study

There is much evidence that domain-general learning is possible, but understanding the breadth of possible transfer will shed light on how different processing mechanisms are related. For example, even though music and language have many parallels, (i.e., a set of sounds that include phrases, intonations, and rhythm; McMullen & Saffran, 2004), evidence of generalization and transfer between language and music is lacking. For this study, rate persistence was measured to examine the possibility of transferring rate information between language and music to investigate the domain-generality of temporal processing. Participants in this study were primed with a fast or a slow rate in either the music or language domains. Then, they were asked to produce their own music or language in the domain opposite of the domain in which they were primed. This investigation of rate persistence tested for the possibility of transfer across the language and music domains.

It is hypothesized that the rate of the prime will affect the rate of production across the language and music domains. Participants primed in the language domain will produce music, and participants primed in the music domain will produce language. If participants vary their rate of speech or music productions after having been primed in the opposite domain, it could be suggested that there is a shared temporal mechanism utilized in processing both language and music. The presence of a shared mechanism between music and language would support a domain-general account.

Method

Participants

Participants were college students taking an entry level psychology course at a regional campus of a major public university in the Midwest. There were a total of 63 students participating in one of two conditions. The music prime/language production condition had 32 participants (8 males, 24 females) with a mean age of 19.41 years, *SD* = 3.52. The language prime/music production condition had 31 participants (12 males, 19 females) with a mean age of 18.97 years, *SD* = 1.89. Approximately half of the participants in each condition received the fast prime block first. An additional three participants were excluded for self-reported hearing problems, eight for outside distractions during the testing process and one for knowing the actual purpose of the study. For their participation in this study, the participants received credit towards their psychology class.

Materials & Apparatus

Participants listened to either language or music priming stimuli through Mercury Innovations headphones. To determine the melodies that would be used for the music productions and the music primes, a pilot study was completed. A total of 27 participants completed a music familiarity survey that contained 88 song titles. They used a 5-point rating scale to indicate how well they knew each song (1 being “Never Heard” and 5 “Very familiar, Could Recite Song). The 25 songs that were rated as most familiar were selected to be the songs that the participants would produce for practice trials and test trials (mean familiarity = 4.963, *SD* = 0.344); the next 20 most familiar songs were utilized as music primes (mean familiarity = 3.815, *SD* = 0.304). Participants received $5 for completing the survey.

Language prime/Music production. Prerecorded fast and slow language audio clips were used to prime the participants with a specific rate. The prime sentences were created while a speaker was listening to a metronome in order to record the stressed syllables at 60 beats per minute (bpm) for the slow rate and 120 bpm for the fast rate. The primes consisted of 20 pictures of a cartoon character engaging in an action. Each picture was paired with a verbal description of the action taking place (e.g., "The girl dried the dish" or "The ball was thrown by the boy"). There were variations in syntax of the sentences; half of the fast as well as half of the slow primes were presented in active voice (e.g., "The girl dried the dish"; see Appendix A), and the other half were presented in passive voice (e.g., "The ball was thrown by the boy"; see Appendix B).

Presentation software on a desktop PC was used to present participants with the stimuli, record their response times, and to produce music. A Stealth Switch II Programmable USB Foot Switch button connected to the USB drive was used to play the melody. Each time the USB Foot Switch button was pressed, one note of the melody would play (song length varied from 6 to 12 notes per melody). The note continued to play for as long as the button was pressed. This allowed the participants to control both the rate of the melody as well as the connectedness of the notes. Music abilities were not necessary to produce a song using Presentation Software, allowing non-musician participants to create music. To familiarize the participants with producing the music stimuli, participants were given the name of a familiar melody and asked to play that melody. The participants were asked to complete five of these practice trial songs before starting the experiment, which contained 20 test songs (see Appendix C).

Music prime/Language production. Prerecorded fast and slow music audio clips were used to prime the participants with a specific rate. There were a total of 20 prime songs, each approximately five seconds long. The prime songs were short familiar melodies digitally produced using Finale software (e.g., It's Raining, It's Pouring or Three Blind Mice; see Appendix D). The slow music primes were recorded at a tempo of 60 bpm and the fast music primes at 120 bpm. There were variations in connectedness of the music notes; half of the fast primes as well as half of the slow primes consisted of either all staccato notes (abrupt, individual notes) or all legato notes (smooth, flowing notes). PowerPoint on a desktop PC was used to present the participants with the stimuli and directions necessary to complete the task. To record the participant's speech, a TASCAM DR-03 digital recorder was connected to the head-mounted microphone. To familiarize the participants with describing the picture stimuli used to record language production, each participant produced five practice trial picture descriptions (see Appendix E). Only the first two included a written description, leaving the participant to create their own description of the last three pictures. The participants then completed the experiment that consisted of producing descriptions of 20 pictures (see Appendix E).

Memory test. A memory test consisting of 16 items pertaining to the primes was completed at the end of the experiment. The participants primed with musical melodies were tested on a subset of these melodies, while the participants primed with sentence descriptions were tested on a subset of these sentence descriptions. For each memory test, half (eight) of the items were from the experiment, and the other half (eight) were foils. The participants recorded their answers on an answer sheet by circling either yes or no as to whether or not they had heard the item. To ensure the participants were not aware of the study's purpose, at the bottom of the answer sheet participants were asked what they believed to be the purpose of the study.

Language prime/Music production memory items. The memory items related to the experiment were actual sentences that had been heard as a prime sentence (see Appendix F). The eight foil memory items were similar in content and length to prime stimuli from the experiment, but had not been used in the experiment. To prevent the participants from being able to use a single word to remember a phrase, the foils contained some of the same words from the prime sentences in the experiment. The foils were balanced for syntactic form and rate such that there were equal numbers of active/passive and fast/slow foils. Of the eight non-foil items, two were the same rate but changed form (i.e., from active to passive and vice versa), two were at a new rate with the same form (i.e., from fast to slow and vice versa), two were a new rate and new form (e.g., change from both active to passive and fast to slow), and two were identical (i.e., the same rate and the same form that they had been in the experiment).

Music prime/Language production memory items. The memory items related to the experiment were actual songs that had been heard as a prime song (see Appendix G). The eight foil items were similar in content and length to stimuli from the experiment, but had not been used in the experiment. To prevent the participants from being able to use a single note to remember a melody, the foils contained some of the same notes as prime songs from the experiment. The foils were balanced for connectedness and rate such that there were equal numbers of staccato/legato and fast/slow foils. Of the eight non-foil items, two were the same rate but changed form (i.e., from staccato to legato or vice versa), two were at a new rate with the same form (i.e., from fast to slow or vice versa), two were a new rate and new form (e.g., change from both staccato to legato and fast to slow), and two were identical (i.e., the same rate and the same form that they had been in the experiment).

Background form. A music and language background form was given halfway through the experiment. The form included questions regarding the participants' music history and preferences, languages spoken, and their past experience with musical instruments and lessons. Thirty five percent of the participants (22 of 63) reported having played an instrument for three or more years. The experiment was blocked so that the participants received either all 10 fast or all 10 slow primes in a row. The rate blocks were separated by the participant filling out the background form. This allowed for the music and language information to be obtained, as well as acting as a counterbalancing tool to ensure the participants were not aware of the rate variation.

Design

There were two cross-domain transfer conditions: music prime/language production and language prime/music production. There was one within-subject independent variable of interest in this study (primed rate: fast, slow), and two within-subject control variables (syntax of language prime: active voice, passive voice or connectedness of music prime: staccato, legato). Rate was blocked across trials so that all 10 fast and all 10 slow primes were in the same block. Connectedness (staccato/legato) of the notes in the music prime stimuli and syntax (active/passive) of the language prime stimuli were randomly distributed throughout the experiment.

The primary dependent variable in this study was the rate of production. For the language productions, independent coders analyzed the timing of each sentence by watching and listening to the waveform in Adobe Audition. This produced a syllable per second rate. Presentation Software was used to analyze the timing of the music production. Each participant's music production was coded for three different elements: the average length of time the button was pressed for each note of a song, the inter-stimulus interval (ISI; the amount of time between each button press for each note of every song), and the average song length (calculated from the button press for the first note of each song until the release of the button on the last note of each song). The secondary dependent variable was memory score as indicated by accuracy on the recognition memory test.

Procedure

Language prime/Music production. The directions were computerized on Presentation, and participants used the USB button to proceed through the instruction slides of the experiment. The participants began the experiment by familiarizing themselves with the procedure. To familiarize the participants with the procedure, the participants were asked to produce five short melodies one note at a time. After the five practice melodies were completed, the 20-trial experiment began. Each trial consisted of a prime and a production. The prime was a cartoon picture paired with a prerecorded description of the action taking place in the picture displayed via Presentation software. For example, participants saw a picture of a girl drying a dish with the verbal description "The girl dried the dish." The production screen gave the participant the name of the song they were to produce. For example, participants saw "After the screen goes black, press button to play each note of It's Raining, It's Pouring," and then they played the song one note at a time by pressing the button. These instructions remained on the screen for 8 seconds for the initial practice trials, but gradually was reduced to 5 seconds by the end of the practice trials and remained 5 seconds for the duration of the test trials. After the last note of the song was played the computer screen displayed "Please Wait". After 2.5 seconds, the experiment progressed to the next prime slide.

Music prime/Language production. The directions were computerized on PowerPoint, and participants used the USB button to proceed through the instruction slides of the experiment. The participants began the experiment by familiarizing themselves with the procedure. To familiarize the participants with the language production task, five sample pictures were shown to the participants. For example, the participants viewed a picture of a cat chasing a mouse, and then they were asked to create a verbal description of the picture (i.e., "The cat chased the mouse"). The purpose of the familiarization process was to acclimate the participants with the verbal expectations of the experiment. Participants were only given feedback if they asked the researcher for further instructions. After the five-trial practice phase was complete, the 20-trial experiment began. Each trial consisted of listening to a short melody and then creating a verbal description of the subsequent picture. Participants proceeded from one trial to the next by pressing the USB button after their verbal picture description was complete.

Across both conditions, the participants were asked to pay attention, as there would be a memory test at the end of this experiment. There were a total of 20 trials divided into 2 blocks based on the rate of the prime (one fast and one slow) with a break in between blocks. During the break, the participants completed a paper and pencil questionnaire inquiring about their music and language background.

After the 20-trial task, the participants in each condition completed a memory test. The participants used pencil and paper to indicate whether the melodies or sentences had been part of the experiment that they had just completed by circling yes or no. Each melody/sentence was repeated twice. The timing that the melodies/sentences were delivered was automatic, such that once the memory task was started, it continued until all 16 items had been delivered. At the bottom of the memory test answer sheet the participants were asked what the purpose of the study was.

Results

Language Prime/Music Production

The average song length (i.e., the amount of time between the button press of the first note until the release of the button on the last note) for each of the participant produced songs was calculated. Both the fast and the slow primed blocks (10 songs in each block) were averaged and compared within subjects. There were no differences in the average song length of the produced songs following either the fast primes (*M* = 5.599 sec, *SD* = 1.424) or the slow primes (*M* = 5.694 sec, *SD* = 1.341); paired-samples $t(30) = -.409$, $p = .685$.

Overall, there were also no differences in rate for duration of average button pressing. The duration of time the button was pressed for every note in each song did not show a difference following either the fast primes (*M* = .376 sec, *SD* = .142) or the slow primes (*M* = .378 sec, *SD* = .131) paired-samples $t(30) = -.142$, $p = .89$. Also, there was no difference found between inter-stimulus interval of music productions (the amount of time that elapsed between button presses for each note) between the fast primes (*M* = .231 sec, *SD* = .070) or the slow primes (*M* = .237 sec, *SD* = .096) paired-samples $t(30) = -.353$, $p = .73$.

Music Prime/Language Production

To determine the length and number of syllables for each sentence description, one of two hypothesis blind coders used Adobe Audition to both visually and auditorily analyze the language .wav files. Of the 32 total participants, 6 were coded by both; average coder agreement on trial length was $r = .96$, and average coder agreement on number of produced syllables was $r = .95$. For the participants that were coded by both coders, the first coder’s data was selected to be used for the final analyses.

For each participant, a syllable per second rate was calculated for each trial and then averaged separately across the first block and the second block of trials. Syllable timing was compared within subjects and showed that language production after the fast primes (*M* = 4.31 syllable/second, *SD* = .81) was faster than language production after the slow primes (*M* = 4.12 syllable/second, *SD* = .78), paired samples $t(31) = 2.82$, $p < .01$. The rate of the participants’ language production was affected by the rate of the music prime whereby they spoke more quickly if they were first primed with fast music in comparison to when they were primed with slow music.

Memory Test

Compared to chance, participants correctly answered whether or not the stimuli had been heard in the experiment, thereby indicating that the participants were accurate overall. Results from the language prime/music production (*M* = 12.099 *SD* = 2.560; one-sample $t(30) = 9.675$, $p < .00)1$ and the music prime/language production (*M* = 11.125, *SD* = 1.827; one-sample $t(31) = 9.675$, $p < .001$) indicate the pretext for the purpose of this experiment was successful in that participants were attending to the prime stimuli in order to remember which stimuli had been heard and which had not. The answers to the open ended question at the bottom of the memory answer sheet, "What was the purpose of this study", further showed that that the participants believed the purpose of the experiment was to test their memory.

Discussion

Research on rate priming within the domains of music and language has shown that the rate of production is affected by the rate of the prime (Jungers, 2007; Jungers & Hupp, 2009). However, information on the ability to transfer information across the music and language domains is lacking. This experiment showed that by measuring rate persistence, the rate at which participants are primed in the music domain has a direct effect on the rate at which language was produced. The rate persistence shows a cross-domain influence between the language and music domains. Being able to prime the participants with a specific rate in the music and have that affect the rate of production in the language domain implies that processing between these two domains is a domain-general function. This indicates that there may be a shared mechanism used for temporal processing in both the language and the music domains.

The possible presence of a shared mechanism is innovative and encompasses an enormous amount of possible teaching, learning, and treatment implications.

For example, research has shown that children with a faster rate of speech who have a family history of stuttering are at a higher risk of stuttering (Kloth, Jansse, Kraaimaat, & Brutten, 1995). Further research involving children with speech impediments such as stuttering has shown that a slowed rate of speech from the mother to a child can decrease the instance of stuttering significantly (Guitar & Marchinkoski, 2001). The mother's slowed speech likely decreases the child's rate of speech (Hupp & Jungers, 2009), which ultimately improves stuttering. If a slower rate of speech can decrease stuttering, and there are shared mechanisms in the brain that process both language and music, could music be added to new forms of speech therapy for those with stuttering problems? The results of this experiment show encouraging evidence that a slowed rate of music could be beneficial when incorporated into speech therapy.

However, the primed rate in the language domain did not affect the rate of music production. There are a variety of possibilities to explain why this was the case. The USB button used to produce music did not require being pressed all the way down in order for the song notes to play, (i.e., a quick tap produced the same result). However, many participants pressed the button down as far as it would go, possibly producing music more according to the time it took to press the button than the rate of the prime. Another possibility concerns the novelty for the participants in producing music in this manner. Non-musicians are typically not afforded the ability to produce their own music by simply tapping a button to create a melody. Practice as well as knowledge of music is usually necessary in order to create music, making the production of music in this fashion an atypical experience.

McMullen and Saffran (2004) have another theory that could explain the lack of effect in producing music after receiving a language prime. They say that although there are established parallels between language and music, the majority of the processing for the two different domains actually takes place in different neurological locations (McMullen & Saffran, 2004). For these reasons, the results of this experiment do not allow for strong conclusions to be made regarding the nature of processing mechanisms. Future research on transfer from the language domain to the music domain could benefit from a device that made the production of music notes easier for non-musicians and musicians alike. Such a device could assist in ruling out a faulty procedure as well as establish the possibility of language to music rate transfer.

Even though rate transfer was only revealed in one direction, domain-generality between the music and language domains as demonstrated in this study shows promising evidence of a shared mechanism used in temporal processing. One possible explanation for domain-general processing can be explained using the entrainment theory (Jones, 1976). According to Jones (1976), in order to explain and understand auditory patterns (i.e., speech), we have to consider the rate at which things are heard. Her explanation includes an internal mechanism that responds to auditory and visual patterns, creating an internal rhythm. Therefore, after listening to a sentence at a fast rate and internally following the rate, transferring that rate to a different domain is likely if the rhythm had been entrained.

The possibility remains that the testing equipment may be at fault for the one-sided results. Further research into domain generalization between music and language would be beneficial to better understand the depth and correlation between these two processing areas. Further, researching the development of this mechanism in childhood could lead to a better understanding of this potential domain-general temporal processing mechanism. Information supporting domain generalization could possibly provide ways to improve language processing by incorporating music and other techniques into teaching or therapy.

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Appendix A

Language Primes Presented in Active Voice

"The boy ate the watermelon."

"The boy made the snowman."

"The girl petted the horse."

"The woman mowed the grass."

"The girl dried the dish."

"The boy threw the ball."

"The boy fed the squirrel."

"The man drove the car."

"The girl drank the water."

"The rhino kicked the ball."

Appendix B

Language Primes Presented in Passive Voice

"The boy was called by the woman."

"The cat was hugged by the boy."

"The batter was mixed by the boy."

"The towel was folded by the girl."

"The cow was milked by the man."

"The guitar was played by the man."

"The picture was painted by the boy."

"The sandwich was eaten by the boy."

"The ball was caught by the boy."

"The tractor was driven by the man"

Appendix C

Melodies used for Music Production Trials

Melodies for Music Practice Production:

Row, Row, Row Your Boat

Jingle Bells

Mary Had A Little Lamb

Twinkle, Twinkle Little Star

Happy Birthday to You

Melodies for Music Production:

You Are My Sunshine

Joy to the World

Hush Little Baby

This Land is Your Land

B-I-N-G-O

Hokey Pokey

Old MacDonald Had a Farm

For He’s a Jolly Good Fellow

Amazing Grace

This Little Light of Mine

The Wheels on the Bus

She’ll Be Coming ‘Round the Mountain

He’s got the Whole World in His Hands

Take Me Out to the Ball Game

Ring around the Rosie

Frosty the Snowman

Rock-A-Bye Baby

I’m a Little Tea Pot

Itsy Bitsy Spider

Do-Re-Mi

Appendix D

Melodies Used as Music Primes

It’s Raining, It’s Pouring

Frère Jacques

Yankee Doodle Dandy

My Country Tis of Thee

Pop Goes the Weasel

Here Comes the Bride

Three Blind Mice

Oh My Darling Clementine

John Jacob Jingleheimer Schmidt

Puff the Magic Dragon

I’ve Been Working on the Railroad

Let Me Call You Sweetheart

Skinnamarink a dink-e-dink

Jesus Loves Me

Supercalifragilisticexpialidocious

Barney Theme Song

Michael Row the Boat Ashore

Home on the Range

When the Saints Go Marching In

Here Comes Peter Cottontail

Appendix E

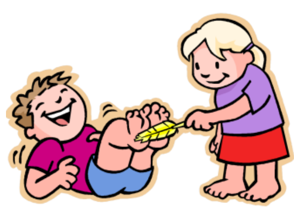
Pictures Used for Language Production Trials

Pictures used for Practice Language Production Trials:

The woman cut the cake.

The man washed the car.

Pictures used for Language Production Trials:



Appendix F

Memory Test Items for Language Stimuli

Memory Item	Trial Type
The man drank the water.	Foil
The butterfly was chased by the boy.	Foil
The hotdog was eaten by the boy.	Foil
The girl smelled the flowers.	Foil
The goat was milked by the man.	Foil
The boy stacked the blocks.	Foil
The truck was driven by the woman.	Foil
The boy flew the kite.	Foil
The sandwich was eaten by the boy.	Same Rate/Same Form
The boy made the snowman.	Same Rate/Same Form
The guitar was played by the man.	Same Rate/New Form
The girl petted the horse.	Same Rate/New Form
The woman mowed the grass.	New Rate/Same Form
The towel was folded by the girl.	New Rate/Same Form
The rhino kicked the ball.	New Rate/New Form
The picture was painted by the boy.	New Rate/New Form

Appendix G

Memory Test Items for Music Stimuli

Memory Item	Trial Type
Let There Be Peace	Foil
99 Bottles of Beer	Foil
Aloutte	Foil
Star Spangled Banner	Foil
America the Beautiful	Foil
If You're Happy and You Know It	Foil
We are Family	Foil
On Top of Spaghetti	Foil
Frère Jacques	Same Rate/Same Form
I've Been Working on the Railroad	Same Rate/Same Form
My Country Tis of Three	Same Rate/New Form
Barney Theme Song	Same Rate/New Form
Three Blind Mice	New Rate/Same Form
Skinnamarink a dink-e-dink	New Rate/Same Form
Oh My Darling Clementine	New Rate/New Form
Jesus Loves Me	New Rate/New Form